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Concussion History in Elite Male and Female Soccer Players

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ABSTRACT

A unique feature of soccer is the purposeful use of the head for controlling, passing, and shooting a soccer ball. Some concern has been expressed in the literature on the cumulative effects of heading on soccer players. Certain neurophysiologic and neuropsychologic changes have been reported in current or retired players, with heading being blamed. A major factor that could influence some of the findings is a player's history of concussive episodes, which are known to influence brain function. These episodes can occur during aspects of the game other than heading. We interviewed all male and female soccer players ($N = 137$, average age = 20.5 years) who competed at the U.S. Olympic Sports Festival in 1993. The mechanisms of injuries, frequency, and sequelae were determined. There were 74 concussions in 39 male players (grade I = 50) and 28 concussions in 23 female players (grade I = 19). For the men, 48 of the 74 episodes were from collisions with another player. For the women, 20 of 28 were from such collisions. Headaches, being "dazed," and dizziness were the most common symptoms reported. Based on concussion history, the odds are 50% that a man, and 22% that a woman, will sustain a concussion within a 10-year period. The data indicate that concussions from player-to-player contact are a frequent hazard in soccer. Head injuries incurred this way may be more of an influence for published findings of physiologic and psychologic deficiencies than routine heading of the soccer ball.

Soccer is a vigorous sport with numerous opportunities for contact that can lead to injuries, mostly involving the lower extremities.[7] The game is unique because the head can be used to purposefully strike the ball. In addition, accidental blows to the head may occur during the course of the game as a player's head strikes the ground, the goalpost, or another player.

Head injuries have been reported to account for 4% to 22% of soccer injuries,[7,10] with concussions reported at between 2% to 3% of all soccer injuries.[2] In the overall spectrum of sports injuries, head injuries in soccer are relatively infrequent. In child and adolescent athletes, concussions from football can account for up to 10% of all injuries.[2] For other sports, concussions as a percentage of all injuries among child and adolescent athletes are 2% in wrestling, 11% in horseback riding, 1.9% in rugby, and 1.7% in soccer.[2] Among adult sports participants, head injuries can account for 9% of injuries in hurling,[19] 6% of injuries in rugby,[2] and 5% of injuries in football.[5] In college football, an 8-year survey of injuries showed that 100 players sustained 175 head or neck injuries with 100 of these injuries being diagnosed as concussions, 84 of which were classified as mild.[1] Considering the frequency of and media attention given to concussions in football, it is surprising that the few reports of long-term sequelae, similar to those found in boxing, are limited to sequelae occurring a few months after the injury.[20]

The effects of repeated concussive episodes are well known. An impact to a person who sustained an earlier concussion from the same type of impact often leads to a more severe concussion.[20] However, there are conflicting reports concerning the effects of repetitive heading. A series of reports studying current and retired professional soccer players has suggested that repeated heading might lead to a subtle, but significant, head injury such as central cerebral atrophy as well as mild-to-moderate neuropsychologic impairment.[13,15–18] In contrast, Haglund and Eriksson[4] failed to find any differences among former amateur boxers, soccer players, or track-and-field athletes in cerebral morphology by CT or MRI, or by neurophysiologic or neuropsychologic findings. However, there were

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differences in electroencephalography and rapid finger-tapping, indicating slight brain dysfunction in some of the boxers. A recent survey of the U.S. National Soccer Team[6] supports the 1993 data of Haglund and Eriksson.[4] The work of Sortland and Tysvaer,[13] Tysvaer and Løchen,[15] Tysvaer and Storli,[16,17] and Tysvaer and coworkers[18] failed to document other factors that could lead to central nervous system disturbances, such as history of alcohol intake and prior concussive episodes. By neglecting to document these factors, the results of these studies could be attributed only to the accumulative effects of heading.

With the continuing growth of soccer in the United States, more physicians will find themselves on the sidelines at games. While the injury profile of soccer involves the lower extremities, it is imperative that those who cover games understand the nature of head injuries in soccer. The general purpose of the survey was to record the history of head injuries in young, elite soccer players. If the players have a history of concussive episodes, a plausible reason for the neurologic deficits reported in the literature might be found.

MATERIALS AND METHODS

The subjects were the 144 participants in the women's and men's soccer competition at the 1993 United States Olympic Festival in San Antonio, Texas. Follow-up telephone interviews were used to complete and clarify the surveys. These surveys contained both specific and open-ended questions. Demographic data and playing history were recorded. Participants estimated the average number of times they headed a ball during a practice and game as well as their frequency of heading the ball compared with other players. Their history of concussive injuries outside of soccer was noted. The players also described symptoms experienced after heading.

The injuries included were those that 1) required the attention of a physician, dentist, or athletic trainer; 2) required removal of the athlete from a game or practice; 3) resulted in stoppage of play; 4) resulted in sequelae; or 5) prevented participation in subsequent games or practices. Less-severe injuries were excluded. Unless the players could report the specific circumstances of each occurrence, we did not include the general recollection of "dazed" symptoms after heading a ball as a specific head injury. This avoided overestimation of the number of concussions.

The mechanisms and circumstances of each injury were recorded. Mechanisms included contact with the ball, another player, the ground, or the goalpost. Circumstances included the player's position at the time of the injury and whether the injury occurred during a game, practice, scrimmage, or drill. Concussions were graded according to the Colorado Medical Society guidelines: grade I, confusion without amnesia; grade II, amnesia without loss of responsiveness; and grade III, complete loss of consciousness. Specific questions were posed about sequelae including headaches or dizziness; difficulty with sleep, hearing, or vision; or other symptoms; and whether the symptoms began after a head injury. Data were summarized using routine descriptive statistics, the chi-square test, and logistic regression.

RESULTS

Seventy-two men and 72 women were surveyed. Complete data were obtained from all the men and 65 (90%) of the women. Six women did not respond and one woman requested that her data be withheld. Descriptive statistics are shown in Table 1. There were six men and two women who reported playing multiple positions. Men were more likely then women to have sustained a concussion. Men had a 2.16-fold higher risk (odds ratio) than women of sustaining a concussion. We were unable to compute an exposure-rate index (for example, injuries per 1000 player-hours or injuries per 1000 athlete-exposures) because players with this much playing experience could not accurately recall the amount of time spent in practice and games or the number of practices and games over their playing careers.

Prior Preventive Measures

All of the men and 62 of the 65 women (95%) reported adequate previous instruction in heading techniques. Preventive measures in youth soccer included padded goalposts, "no heading" rules, and using the age-appropriate

TABLE 1
Study Population Evaluated by Age, Body Size, Soccer Involvement, Frequency of Heading the Ball, and Position

Characteristic	Men (N = 72)	Women (N = 65)	Overall (N = 137)
	Mean (range)	Mean (range)	Mean (range)
Age (years)	19.1 (17–22)	22 (17–30)	20.5 (17–30)
Height (inches)	70.6 (64–75)	65.7 (61–70)	68.24 (61–75)
Weight (pounds)	169.1 (130–200)	131.8 (105–155)	151.37 (105–200)
Began soccer at (years)	6.6 (4–12)	7.8 (4–15)	7.2 (4–15)
Played organized soccer (years)	13.0 (8–17)	14.2 (7–20)	13.6 (7–20)
Estimated heads/practice	9.5 (0–40)	8.6 (0–50)	9.05 (0–50)
Estimated heads/game	7.3 (0–35)	8.4 (0–50)	7.85 (0–50)
Position (N)			
Forward	19	17	36
Midfield	29	22	51
Defense	22	20	42
Goalkeeper	8	8	16

ball (Table 2). Estimated frequency of heading is listed in Table 1. The players' estimates of their relative frequency of heading is listed in Table 3.

Symptoms After Heading the Ball

Over half the players reported they had experienced at least one headache after heading the ball, and there was no overall difference in this incidence between men and women. There was a large variation in the frequency and duration of these episodes. Men reported headaches lasting from 2 seconds to 2 hours (median time, 1 minute), while women reported headaches lasting from 12 seconds to 25 days (median not recorded). Exertion made the headaches worse in five men and three women, while six men noted "flashing lights." Throbbing headaches were described by 26 men and 20 women. Bilateral symptoms were experienced by 13 men and 14 women. Only one man had unilateral symptoms. The most common location given for headaches was frontal (11 men and 21 women). Two female participants reported having amnesia after heading. Other symptoms are listed in Table 4.

Headaches were associated with poor technique or hitting the ball with any area besides the frontal portion of the head by 23 men and 31 women. A heavy or overinflated ball was blamed for headaches by 15 men and 9 women. Hot or cold weather was a factor cited by five men and two women. Two men mentioned that they had headaches after repeatedly hitting the ball during a practice or game. The players who had traveled overseas described playing with balls there that seemed to have increased air pressure, heading balls with excess spin, or heading balls that had been kicked harder than they were used to in the United States.

Head Injuries

Concussions. The cumulative number of player-years for the 72 men and 65 women surveyed was 939 and 924, respectively. We could not estimate the total number of games or practices. Sixty-four male players (89% of the men, including all the goalkeepers) and 28 female players (43% of the women, including 5 of 8 goalkeepers), had experienced some type of head injury during their soccer careers. Only the forwards had significantly fewer concussions than the goalkeepers. There were no differences in the history, frequency, or severity of concussion among other field players. Table 5 lists the occurrences of head injuries reported by the subjects in this survey. We did notice a significant increase in the occurrence of injuries, number of players experiencing a particular injury, severity of concussion, and headaches with an increase in the subjects' Quetelet ratios.

Based on the history of head injuries and years of experience of a large group of athletes, it may be possible to suggest the probability of a player sustaining a head injury based on years of experience. We performed a logistic regression with the occurrence of a concussion (yes or no) as the dependent variable and years of playing experience as the independent variable. From the equation coefficients, probabilities can be determined. For example, we determined that there was a 50% probability that a male player would have a concussion within a 10-year playing period and a 22% probability that a female player would suffer a concussion during a 10-year playing period.

There was a total of 74 concussions in the men and 28 in the women. In terms of concussion severity, women had significantly less-severe concussions. Multiple concussions were reported by 24 men and 3 women. Table 6 lists the primary mechanisms of concussions. The most common mechanism was a collision with another player, while the least frequent mechanism was a collision with the goalpost. Grade I concussions were the most common (Table 7). Among players who reported amnesia, the median length of the amnesic episode was 1.5 minutes for the men and 5.75 minutes for women. The median time of confusion was 5 minutes for the men and 8 minutes for the women.

Sequelae. Late sequelae were reported by five men (6.9%). Two players reported recurrent headaches after concussive injuries. One of these players had an episode of severe vertigo 9 months after a concussive injury in which he had also sustained multiple facial and oral fractures. Although the vertigo did not recur, the player has had occasional episodes of visual flashes or floaters and persistent apprehension concerning potential reinjury. One

TABLE 2
Percentage of Players Who Recall Measures to Prevent Heading Injuries

Measure	Men	Women
Adequate instruction	100	95.4
Instruction as a youth	75	90.1
Use a smaller ball	72	26
"No heading" rules	1.4	0
Padded goal posts	1.4	0

TABLE 3
Players' Estimates of Their Relative Frequencies of Heading the Ball (Percent)

Frequency	Men	Women
Much less than most	15.3	18.5
Less than most	19.4	21.5
About the same	30.6	32.3
More than most	22.2	20.0
Much more than most	12.5	7.7

TABLE 4
Percentage of Players Having Post-Heading Symptoms by Sex[a]

Symptom	Men	Women
Headaches	54	55
Dazed	31	49
Dizziness	18.1	38.5
Decreased concentration	9.7	10.8
Blurred vision	11.1	4.6
Lost consciousness	1.4	0
Numbness/tingling	12.8	7.7
Amnesia	0	3.1

[a] Multiple responses were permitted.

TABLE 5
Number of Head Injuries by Injury Type, Player Position, and Sex[a]

Injury	Men		Women	
	All positions	Goalkeepers	All positions	Goalkeepers
Total head injury episodes[b]	168/64	28/8	41/28	8/5
Concussions	74/39	14/5	28/23	7/5
Fractures	15/10	3/1	9/7	0
Lacerations	38/27	4/3	9/9	1/1
Nose bleeds	30/25	5/4	5/5	0
Eye injuries	6/5	3/2	1/1	0
Mouth injuries	20/16	5/3	5/5	1/1

[a] Number of injuries/number of players with that injury.
[b] An injury episode is a single incidence; an episode might have one or more than one injury.

TABLE 6
Number of Players with Concussions by Mechanism of Injury

Mechanism of injury	Men	Women
Collision with another player	48	20
Collision with the ground or indoor wall	10	3
Collision with the goalpost	1	2
Collision with the ball	15	3

TABLE 7
Number of Players with Concussions by Concussion Grade and Sex

Grade	Men	Women
I	50	19
II	22	5
III	2	4
Total	74	28

player had a subsequent endodontic root canal procedure after a tooth that had been loosened in a collision became abscessed. Another player had occasional dreams about losing teeth related to an injury 4 years before when he had lost 2 maxillary incisors. A fifth player has repeated episodes of unilateral fist clinching when inadvertently struck on the occiput with the ball. These symptoms were still recurring more than 2 years after the initial episodes. All of the men reporting sequelae blamed a prior head injury.

Eleven women (17%), only one of which was a goalkeeper, reported possible late sequelae. Headaches were the most common symptom, reported by nine women (14%). Three women had associated dizziness, and one still reports difficulty sleeping. Of these nine women, three reported, without prompting, a family history of migraine headaches. Two other players experienced neurologic symptoms without headaches: chronic neck pain, and four to five episodes of paresthesia of the right arm radiating to the digits.

Only three women believed that their present neurologic symptoms began after a head injury, and one woman was "uncertain." This latter woman previously had one grade I concussion and, at the time of the survey, averaged one headache per week. The other three women had varying histories. One woman experienced chronic neck pain after a "head butt" she had sustained with a concussive injury while attempting to head the ball. A second woman had activity-related headaches 4 years after a grade I concussion that resulted when she tripped and struck her head on the ground. The third woman had three-to-four headaches per month, each which lasted from 6-to-12 hours. Although she reported that these had begun with a head injury, she denied symptoms consistent with previous concussive injuries. She did report two nonconcussive injuries: one nosebleed and one lip laceration.

DISCUSSION

Soccer is unique among sports in that the head can be used in a purposeful manner to strike the ball. The ball size, weight (396 to 453 g), speed of flight, coating, inflation pressure, and elasticity, and the weather conditions, including temperature and humidity, all can affect the forces on the head from heading the ball. Head and neck injuries can account for up to 22% of all soccer injuries.[7,10] Concerns have been raised about the cumulative effects of multiple blows to the head that occur when heading the ball. Schneider and Lichte,[11] as cited by Smodlaka,[12] reported that a ball kicked with half power could travel at 22 m/s or 82.3 km/hr and strike the head with 116 kp of force. They estimated that the impact increases to 200 kp when the ball is kicked with full power. With about five heading opportunities per game,[9] plus an unknown number during training, the concerns about cumulative effects of heading seem appropriate. The risk is a concern in light of the neurologic sequelae experienced by some former boxers.

Some authors attribute long-term neurologic dysfunction to heading. Tysvaer and Storli[16] have documented neurophysiologic and neuropsychologic changes in current soccer players. Tysvaer and Løchen[15] and Tysvaer et al.[18] have documented such changes in retired soccer players. Forty-three percent of the players complained of symptoms normally attributed to postconcussion syndrome such as dizziness, headache, irritability, impaired memory, and lack of concentration.[16] Abnormalities were more evident in the EEGs of players than on those of matched controls. Neuropsychologic testing showed that 81% of the players had deficits in attention, concentration, memory, and judgment.[15] Using CT evaluation, Sortland and Tys-

vaer[13] found that one-third of retired players (average age, 52 years) had values for central cerebral atrophy that were outside the 95% confidence interval for published norms. These authors attributed their findings to the cumulative effects of heading the ball in soccer. However, they did not account for other well-documented factors known to cause neurologic dysfunction. These include alcohol use and previous concussion history.

Haglund and Eriksson[4] compared Swedish amateur boxers, soccer players, and track-and-field athletes for evidence of brain damage. There were no physical, neurologic, CT, or MRI differences between the groups. The boxers had a significantly higher incidence of slight or moderate EEG deviations when compared with the track-and-field athletes. On neuropsychologic testing, boxers who had fought more than 30 matches performed poorly on both dominant and nondominant finger-tapping tests, when compared with the other two groups. Significant negative correlations were found between finger-tapping performance and the following: length of soccer career, length of boxing career (in those with more than 30 matches), and number of boxing bouts (also in those with more than 30 matches). That there were no differences between the soccer players and track-and-field athletes argues against any significant cumulative head injury from soccer. The lack of true control groups limits the generalizability of these findings. More recently, the U.S. National Soccer Team as well as highly trained track-and-field athletes underwent MRI imaging of their heads and completed surveys about head injury symptoms and screens for alcoholism. There were nine soccer players with positive MRI findings (for example, cortical atrophy, ventricular enlargement, focal atrophy, and cavum septi pellucidi). Similar findings were found in the six track-and-field athletes. The only significant correlation with head injury symptoms was with history of head injury in the soccer players ($r = 0.63$)

Even if the EEG abnormalities reported in the literature are confirmed, we question the association of repeated heading as the sole cause of these. Our data show that nearly 90% of the men had some history of head injury and 54% reported a history of concussion. It seems inaccurate to blame heading for the findings of EEG abnormalities when concussive injuries happen to so many players. Although a small proportion of concussions come from heading the ball itself (18 of 102, or 18%), a higher proportion come from the act of heading when another player's head is struck rather than, or in addition to, the ball. Of the 102 concussions we recorded, 68 involved collisions with another player and many of these occurred during the act of heading.

Concussions resulted most frequently from a collision with another player (Table 6). Many of the changes associated with boxing are noted to be in response to multiple concussive blows to the head.[3] Thomassen et al.[14] suggested that permanent brain damage in boxers was the cumulative result of multiple mild traumas as opposed to knockouts. The unanswered question is whether routine heading constitutes "multiple mild trauma." A further question is whether a previous concussion lowers the threshold for neurologic sequelae enough to make subsequent routine heading of the ball a dangerous activity.

The increase in concussions among players with larger Quetelet ratios is interesting. These larger players are likely the ones targeted on air balls, and their size puts them at an advantage for playing the ball with their head. The finding that most head injuries result from a collision with another player should not be surprising because the larger players would be expected, by virtue of their size, to challenge for heading opportunities more often than their smaller teammates.

A different injury rate for men and women was documented in the Norway Cup competition.[8] While we did not show a significant difference in head injuries between the sexes, more women reported symptoms like dizziness and being dazed from heading, while more men reported numbness and blurred vision (Table 4). These differences in symptoms between men and women may be attributed to the women's smaller mass, greater ball-to-head-size ratio, and possible lesser neck strength, as well as a subjective impression that there is more heading in women's games than in men's.

We noted a small percentage of players with persistent neurologic symptoms or sequelae. Our results may be attributable to such factors as our subjects' shorter playing careers or reticence to provide information because of fear of retribution (for example, being withheld from future competitions because of their answers). Another factor accounting for the differences in our results from those of Sortland and Tysvaer,[13] Tysvaer and Løchen,[15] Tysvaer and Storli,[16,17] and Tysvaer et al.[18] may be the fact that many of the athletes in these studies played before the use of modern plastic-coated balls. The modern ball absorbs less water and transmits less force to the head when wet.

Our results are limited because they are retrospective and have several biases. First, there is a selection bias that limits the generalizability of the data. Our sample size was small and limited to high-level soccer players. By virtue of their playing histories, a greater commitment to aggressive competitive play should be expected than among the general soccer-playing population. The speed of the game, potential for contact, and aggressive pursuit of balls played in the air would be expected to be features of this high level of play. It is even difficult to compare these data with the database of the National Collegiate Athletic Association, which represents a cross-section of member colleges, not just the elite of the sport. Our players were in the elite category and they may have had access to better coaching and equipment. However, the high caliber of the players does not mean they may have had more heading opportunities because of the excessive numbers of games and practices. Most of our subjects were collegiate players, at colleges across the whole country, who are restricted in the number of games and practices allowed. Their European or South American counterparts may play two to three times as many games a year, increasing their exposure to head injuries. It would be unwise to apply these findings to a group of recreational players of any age.

Second, there is a recall bias. We were relying on the players to give honest answers to the queries. In addition,

it is difficult to compare these data with those in the literature because of the subject mix. Retired players may report injuries more accurately than active players because they do not fear being removed from competition. However, retired players might have forgotten past episodes. This might have made the more serious injuries appear to have been more frequent because minor injuries were forgotten. It is also difficult to ask players about amnesia since the only accurate answer for how long one could not remember is, "I cannot remember." The lack of a control group is also a limitation, as this study was not a true case-control design. Future work in this area should be prospective in nature within the various levels of play to accurately document the incidence of head injuries.

CONCLUSIONS

It is difficult to distinguish whether acute concussive injuries or cumulative heading injuries caused the neurologic changes that have been reported in the literature. Even the literature itself is ambiguous on this point. The large number of players who have sustained head injuries suggests that repetitive concussive injuries from a variety of sources should be considered as a factor in late neurologic changes. Properly executed heading did not result in any concussive episode in any of our subjects. From a preventive viewpoint, players should attempt to avoid collision with other players, especially during heading. We see no reason to view reduction in properly executed heading as a means to reduce the neurologic sequelae discussed in the literature. The fact that repetitive concussions have been implicated in boxers' neurologic changes does not mean that *any* heading, particularly that which does not lead to concussions, should be considered as the primary cause of neurologic changes. A follow-up study on soccer players without history of concussions would be instructive. Clearly, the risk of head injury and potential neurologic sequelae warrant further study by the sports medicine community.

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